Development of the Nonhydrostatic Unified Z-Grid Icosahedral Model (UZIM) at CSU

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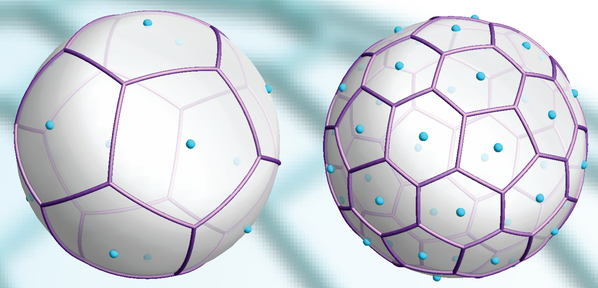
Overview:

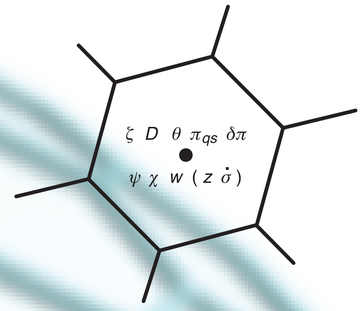
We present a global nonhydrostatic dynamical core based on the unified system of equations (Arakawa and Konor, MWR, 2009; and Konor, MWR, 2014). The dynamical core uses an icosahedral horizontal grid and Z-grid staggering (Randall, MWR, 1994). We call the model the Unified Z-grid Icosahedral Model (UZIM). There are two versions of UZIM: 1) the height vertical coordinate version which uses a Lorenz grid (UZIM-height), and 2) the hybrid sigma-pressure coordinate version which uses a Charney-Phillips grid (UZIM-sigma). The quasi-hydrostatic version of UZIM-sigma has been completed. The nonhydrostatic version of UZIM-sigma is being tested. We have just completed the development of the quasi-hydrostatic portion of the hybrid isentropic-sigma UZIM.

Grid generation starting from an icosahedron

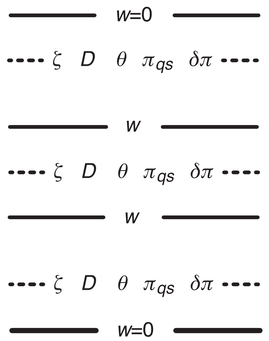


Grid generation, optimization and operator accuracy is discussed by Heikes et al. (MWR, 2013)

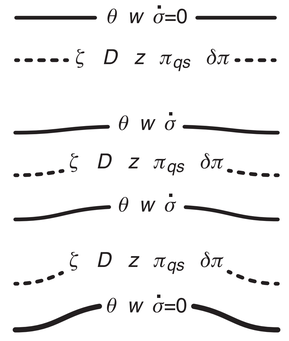
Distribution of variables on the Z-grid



Vertical L-grid of UZIM-height

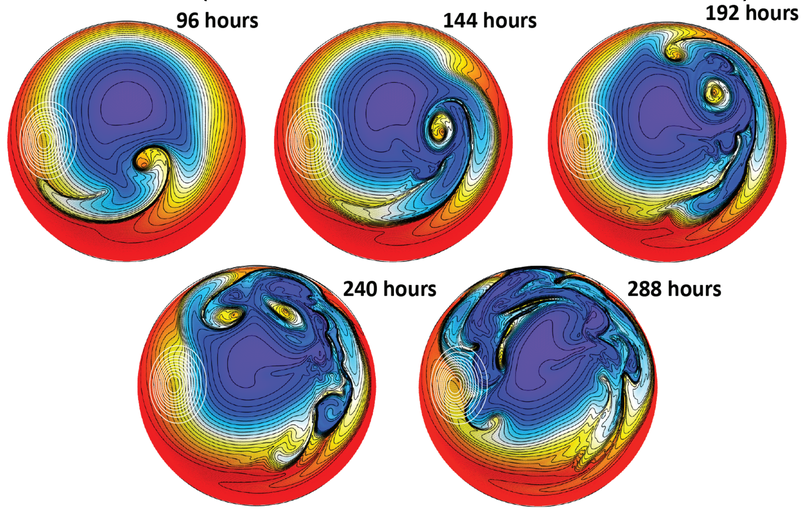


Vertical CP-grid of UZIM-sigma



Quasi-Hydrostatic Idealized Extratropical Cyclogenesis Experiment with a Mountain (UZIM-sigma)

Surface theta (2 km-mountain is indicated with white circular contours)

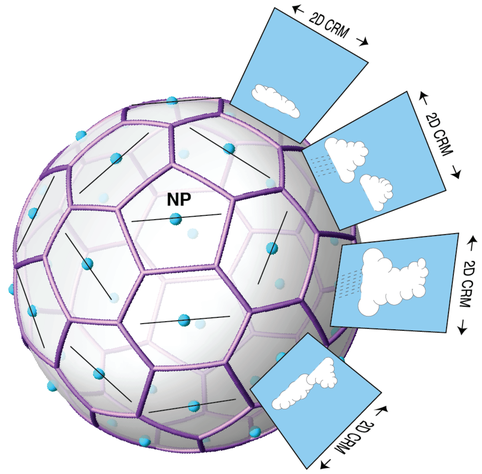


G7 (grid distance=60 km) 32L (vertical grid distance=500 m)

Initial jet from Williamson and Jablonowski (NCAR Notes, 2006)

Inclusion of Super-Parameterized Physics in UZIM-height

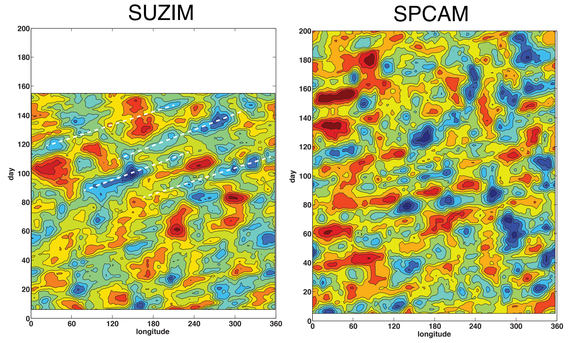
UZIM-height GCM and 2D CRM channels



GCM and CRMs run at G5 and 4 km horizontal resolutions, respectively. CRMs have 128 km horizontal domains with periodic lateral boundary conditions.

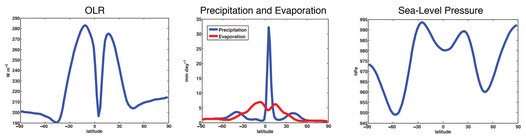
Vertical domains of both models are 30 km deep and they share the same 30-level stretched vertical grids.

Hovmuller diagram of OLR
(11 days running means between 15ºS and 15ºN)

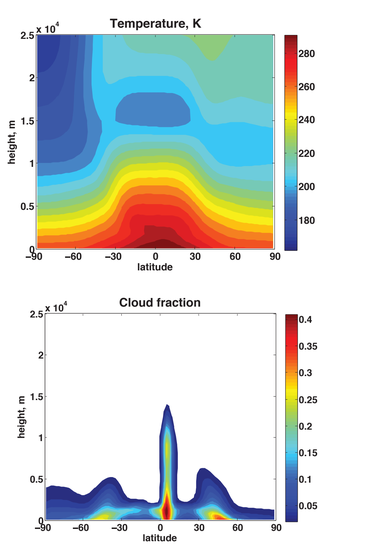


Eastward propagation is clearly seen.
There is an inconclusive evidence of MJO signal.

Some zonal mean quantities

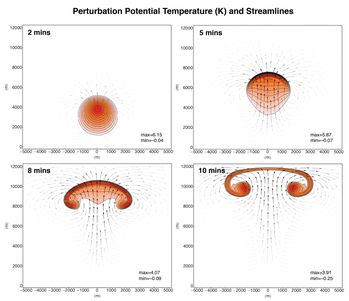


Some zonal mean cross-sections



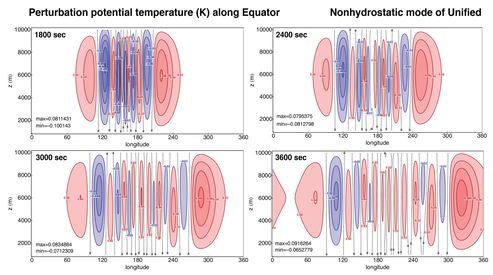
Warm Bubble Experiment (UZIM-height)

G7 (gd=60 km) 32L (dz=500 m) a=300 km



Nonhydrostatic Gravity Wave Propagation (UZIM-height)

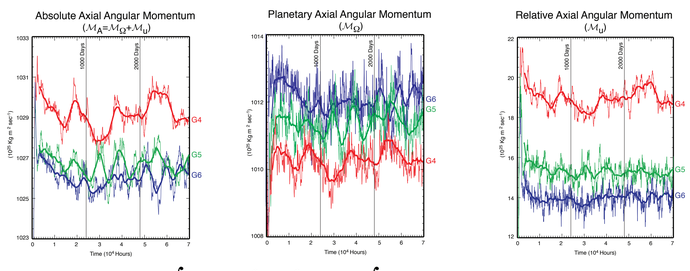
G7 (gd=60 km) 32L (dz=500 m) a=300 km



See DCMIP website (https://www.earthsystemcog.org/projects/dcmip-2012/) for comparison to other models

Conservation of Axial Angular Momentum (AAM) (with Q-H UZIM-sigma)

Held-Suarez runs with G4, G5 and G6 resolutions to examine conservation of the AAM.



$$\mathcal{M}_A = \mathcal{M}_\Omega + \mathcal{M}_u = \int_V \rho_{qs} \Omega a^2 \cos^2\varphi \, dV + \int_V \rho_{qs} u a \cos\varphi \, dV$$

See Lebonnois et al. (JGR, VOL. 117, 2012) for comparison to other models

Plans:

We will implement the super-parameterization in UZIM-sigma with realistic mountains. We will implement the Unified Parameterization of Arakawa and Wu (JAS, 2013) to UZIM-sigma, which allows us to run the model in wide range of resolutions including those in the nonhydrostatic range. For tests, CAM5 physics will also be implemented.

We will compare results obtained with the CAM5 physics, the Unified Parameterization, and the super-parameterization.

DOE PI meeting, 11-15 May 2014, Washington DC